THE EVOLUTION OF INFORMATION MANAGEMENT IN OCEAN EXPLORATION

Brendan Reser[1], Sharon Mesick[2], Elizabeth Lobecker[3] Webb Pinner[4]
Supporting NOAA's Office of Ocean Exploration and Research

1. General Dynamics Information Technology, Bay St. Louis, MS
2. National Coastal Data Development Center, Stennis Space Center, MS
3. ERT Inc, Durham, NH
4. Acentia, Inc Narragansett, RI

Paradigm Shift through Telepresence Technology

Ocean exploration and research have traditionally been conducted by a small sea-going team of scientists and technicians. This approach limits immediate scientific collaboration and insight to the team aboard ship. The application of telepresence technology to ship-based exploration shifts this paradigm, enabling information access for personnel on shore and effectively extending the expertise, skills and capabilities of the shipboard team.

NOAA Ship *Okeanos Explorer* is equipped with a Very Small Aperture Terminal (VSAT) which transfers data from ship to shore. Standard procedures for organizing data aboard ship, coupled with a prioritized data transfer protocol, ensure continual shore-side access to shipboard data. Exploration Command Centers are the hub of shore-side operations, where members of the shore-side science party gather to analyze data and to collaborate with shipboard colleagues. Subsets of information are also available to the public via online maps and public outreach sites. Shipboard systems are optimized to support proper data documentation and long term data stewardship.

In July 2012 the NOAA *Okeanos Explorer* Program, National Science Foundation (NSF) and Woods Hole Oceanographic Institution (WHOI) engaged in an experimental cruise to determine the feasibility of integrating the Sentry AUV into telepresence enabled exploration. The team spent two weeks acquiring data with the Sentry AUV and standard shipboard systems. The remote science party including scientists, students, and AUV team members successfully participated in AUV operations via telepresence from Exploration Command Centers (ECCs) located throughout the U.S.

Data Synchronization Procedure

Shipboard servers are synchronized with shore-side servers through a tiered synchronization procedure. Designated high priority files (Tier 1) supersede files of lower importance (Tier 2, Tier n…) in the transfer process. The procedure reinitializes hourly, and runs continually until all of the targeted files have been transferred.

File prioritization is flexible to adapt to scientist's needs. Sentry cruise data transfer priorities were as follows:

Tier 1: Ship Sensor Data, Sentry Navigation Data; Raw Sensor Data; Photos; Reports

Tier 2: Ship Multibeam Products, Sentry Multibeam Products; Video Compilations; Sidescan Sonar

Tier 3: Ship CTD; EK60; ASVP

Tier n: Catch-all tier for remaining files

Seirios Camera Sled

Little Hercules ROV

Comprehensive and Standardized Data Management

Scientific data collection and ship-to-shore information flow commence when *Okeanos Explorer* sails. Data products, reports and other mission information created by shipboard personnel are stored in the Ship-Board Repository Server (SBRS) in a standardized directory structure.

The Shore-side Repository Server (SRS) is an information collection/dissemination point that synchronizes hourly with the SBRS to provide near real-time access to cruise data and information products. Ship and shore-based personnel use the SRS as a data exchange location to access and review the previous day's information, discuss results, and make planning decisions.

Okeanos Explorer data management processes implement cross platform, open source utilities and protocols to standardize the organization of shipboard data collections. Standard operating procedures ensure uniform file structures and file naming conventions are enforced, which enable process automation and optimization. Synchronized data transfer protocols move data from the SBRS to the SRS. This standardized methodology allows for the easy integration of new sensors and systems, such as the Sentry AUV, into the data management workflow.

During the Sentry cruise a separate network, maintained by the WHOI Sentry AUV Team, was set up on the *Okeanos Explorer* to isolate the WHOI data collection and processing software from the shipboard networks. Post-collection, selected datasets were migrated to the SBRS via hard drive transfers. These datasets were prioritized for inclusion in the synchronization protocol for shore-side transfer via the VSAT at 10 mbps.

Optimized information sharing in a timely manner enabled joint data analysis and production by shipboard science and technical personnel working collaboratively with teams at the ECCs at the Inner Space Center at the University of Rhode Island and at WHOI.

Outcome

Sentry AUV operations were successfully integrated into telepresence-enabled exploration. During the mission, joint data analysis and production were conducted by shipboard science and technical personnel working collaboratively with the remote science team at the ECC located at the Inner Space Center at the University of Rhode Island and at WHOI.

Successes:
- Data management methods were adapted for Sentry data collections. Ship-to-shore operations were coordinated for
  - Joint data processing
  - Mission planning and dive programming
  - Data analysis
  - AUV launch/recovery

Lessons learned:
- Maintaining separate operational networks for the Sentry and *Okeanos Explorer* shipboard systems created a bottleneck in the data transfer process. Additional workflow optimization could reduce file duplication, which was created by some of the manual efforts involved in data transfer between networks and distributed systems.

Next steps:
- Improvement of data exchange protocols between sensor networks and shipboard networks will enhance workflow and reduce file duplication .
- Additional operational testing of AUV operations with *Okeanos Explorer* in "full exploration mode" – that is, with ROV operations, AUV and mapping systems jointly engaged in one mission – has the potential to maximize data use for mission planning (e.g.) reconnaissance prior to ROV dive).
- Further integration of Sentry AUV data into the *Okeanos Explorer* automated data management workflow will address data stewardship requirements for Sentry data collections.
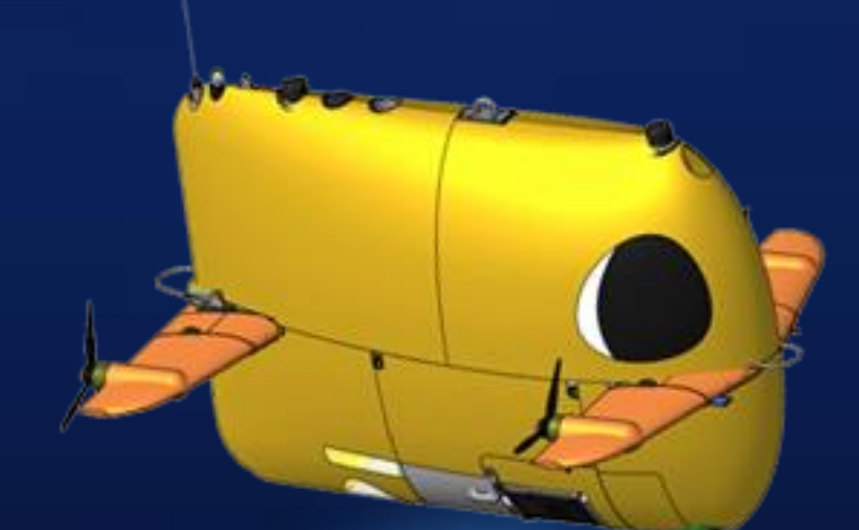
Exploration Command Centers (ECC)

ECCs are shore-side locations where cruise participants gather to collaborate with shipboard crew during missions. Data transmitted through the VSAT and disseminated over Internet 2 are viewed in high definition. RTS audio units and a live chat room allow scientists at these locations to direct, analyze, and provide commentary on cruise activities in real time.

Sentry AUV

Multibeam Data · SBRS · Rsync · SRS · Shore-side Scientists · ROV/AUV Data · Reports, Products · Automated Archival Process · Public Access

explore.noaa.gov